Claims

What is claimed is:

1. A sensor for logging a formation resistivity while drilling a well using an oil-based mud, comprising:
   a sensor body;
   a first current injector electrode disposed on the sensor body, wherein the first current injector electrode is electrically insulated from the sensor body;
   at least two current return electrodes disposed on the sensor body at a selected distance from the first current injector electrode, wherein the at least two current return electrodes are disposed proximate to each other and are electrically insulated from the sensor body; and
   an electrical source configured to energize the first current injector electrode with a current having a voltage of no less than 50 mvolts and a frequency of no less than 1 KHz.

2. The sensor of claim 1, wherein the electrical source is configured to energize the first current injector electrode with a current having a voltage in a range from 50 mvolts volts to 1000 volts and a frequency in a range from 1 KHz to 1.5 GHz.

3. The sensor of claim 1, wherein the electrical source is configured to energize the first current injector electrode with a current having a voltage of about 100 volts and a frequency of about 50 MHz.

4. The sensor of claim 1, wherein the first current injector electrode is a ring electrode and the at least two current return electrodes are button electrodes.

5. The sensor of claim 1, wherein the at least two current return electrodes are separated from each other by about 1 inch.

6. The sensor of claim 1, wherein the sensor body is part of a drill collar.

7. The sensor of claim 1, wherein the sensor body is part of a deployable pad of a downhole tool.

8. The sensor of claim 1, wherein the sensor body is part of a downhole tool, and wherein the first current injector electrode is disposed on a drill collar and the at least two current return electrodes are disposed on at least one deployable pad of the downhole tool.

9. The sensor of claim 1, wherein the at least two current return electrodes comprise three current return electrodes arranged in a linear configuration with an substantially equal distance between each neighboring pair.

10. The sensor of claim 9, wherein the substantially equal distance is about 1 inch.

11. The sensor of claim 9, wherein the first current injector electrode is a ring electrode and the three current return electrodes are button electrodes

12. The sensor of claim 9, wherein the electrical source is configured to energize the first current injector electrode with a current having a voltage of about 100 volts and a frequency of about 50 MHz.

13. The sensor of claim 9, wherein the sensor body is part of a drill collar.

14. The sensor of claim 9, wherein the sensor body is part of a deployable pad of a downhole tool.

15. The sensor of claim 9, wherein the sensor body is part of a downhole tool, and wherein the first current injector electrode is disposed on a drill collar and the three current return electrodes are disposed on at least one deployable pad of the downhole tool.

16. The sensor of claim 1, further comprising a second current injector electrode disposed on the sensor body and spaced apart from the first current injector electrode such that the first current injector electrode and the second current injector electrode are substantially symmetrically displaced from the at least two current return electrodes.

17. The sensor of claim 1, wherein the first and second current injector electrodes are ring electrodes and the at least two current return electrodes are button electrodes

18. The sensor of claim 16, wherein the electrical source is configured to energize the first current injector electrode and the second current injector electrode with a current having a voltage of about 100 volts and a frequency of about 50 MHz.

19. The sensor of claim 16, wherein the sensor body is part of a drill collar.

20. The sensor of claim 16, wherein the sensor body is part of a deployable pad of a downhole tool.

21. The sensor of claim 16, wherein the first and second current injector electrodes are energized at different times.

22. The sensor of claim 16, wherein the first and second current injector electrodes are energized with different frequencies.

23. A method for determining a formation property, comprising:

injecting a current into a formation by energizing a current injector electrode;

measuring a property of a first current returning to a first current return electrode disposed at a distance from the current injector electrode;

measuring a property of a second current returning to a second current return electrode disposed proximate the first current return electrode; and

determining the formation property from a difference measurement derived from the property of the first current and the property of the second current.

24. The method of claim 23, wherein the formation property is a formation impedance or a formation resistivity.

25. The method of claim 23, wherein the property of the first current and the property of the second current relate to one selected from a signal amplitude, a phase shift, an and amplitude attenuation.

26. The method of claim 23, further comprising:

measuring a property of a third current returning to a third current return electrode disposed proximate the second current return electrode, wherein the second current return electrode is disposed at an substantially equal distance to the first current return electrode and the third current return electrode; and

comparing the property of the first current, the property of the second current, and the property of the third current to monitor a tool standoff effect.

27. The method of claim 23, wherein the method is performed while drilling a well using an oil-based mud.

28. The method of claim 27, further comprising controlling a drilling direction based on a parameter selected from the determined formation property, the property of the first current, the property of the second current, the difference measurement, and a combination thereof.

29. A method for determining a formation property, comprising:

injecting a first current into a formation by energizing a first current injector electrode;

measuring a property of a first current returning to a first current return electrode disposed at a distance from the first current injector electrode;

measuring a property of a second current returning to a second current return electrode disposed proximate the first current return electrode;

injecting a second current into the formation by energizing a second current injector electrode;

measuring a property of a third current returning to the first current return electrode;

measuring a property of a fourth current returning to the second current return electrode; and

determining the formation property from a difference measurement derived from the property of the first current, the property of the second current, the property of the third current, and the property of the fourth current.

30. The method of claim 29, wherein the formation property is a formation impedance or a formation resistivity.

31. The method of claim 29, wherein the method is performed while drilling a well using an oil-based mud.

32. The method of claim 31, further comprising controlling a drilling direction based on one selected from the derived formation impedance, the property of the first current, the property of the second current, the property of the third current, the property of the fourth current, and the difference measurement.

33. The method of claim 29, wherein the injecting the first current and the injecting the second current are performed at different time.

34. The method of claim 29, wherein the injecting the first current and the injecting the second current are performed at different frequencies.